Risk Management Integration into Complex Project Organizations

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Abstract—With the continually evolving project environments, NASA has moved from a monolithic to a decentralized project structure. Risk management is an integral part to the success to any project. To accommodate the challenges in this evolving team environment, new and innovative ways to communicate problems and concerns that would affect a project have to be developed quickly and effectively. These problems are compounded when the project teams have partners that are not collocated. New ways need to be developed to handle NASA's missions with smaller budgets and shorter design and development cycles.

In addition, NASA funded projects have a requirement to abide by *NASA Procedures and Guidelines, Program and Project Management Processes and Requirements* (NPG 7120.5A) guidelines. [1] As part of these guidelines, procedures and processes for implementing risk management must be developed and documented. A consistent manner of handling risks on a project must be implemented to provide effective communication, ease of use, data analysis, and provide a source of lessons learned.

NASA's Space Infrared Telescope Facility (SIRTF) project recently developed and implemented a web-based risk management system. This implementation has been further refined to accommodate the needs of other projects, and to further assist a project in meeting NPG 7120.5A requirements. The Risk Management Entry Tool can have two configurations that provide the flexibility to track information either qualitatively or quantitatively. Both configurations can be tailored to the needs of a project based on individual project requirements and can provide simulation capabilities to the risk administrator.

This paper describes the approach used in designing and adapting the SIRTF prototype, discusses some of the lessons learned in developing the SIRTF prototype, and explains the adaptability of the risk management database to varying levels project complexity. Overall strategy of developing a risk management system is also discussed.

1. Introduction

Projects have changed over the last 25 years. Once projects were monolithic in structure with all aspects performed by a single institution. Today, components and functions of a project are delegated to different institutions and even nations, and often include specialized contractors. In the SIRTF Project there are six main institutions that are responsible for different aspects of the project. These institutions are geographically distant, creating challenges with travel and communications. The SIRTF Risk Management system was developed from necessity as well as the need to communicate problems and concerns quickly and effectively throughout the project.

Historically, risk management has always been implemented for NASA projects, although not formally identified. According to Rose, "The current methodology derives from pioneering efforts on successful projects of the mid-90s."[2] There was no system in place that would capture a project's risk knowledge. The Risk Management Entry Tool was developed with a primary requirement of capturing this knowledge.

The requirements for the Risk Management Entry Tool include providing:

- risk knowledge management capture
- a tool to aid in the compliance of NASA NPG 7120.5A requirements
- reports for project management
- an easy way to organize risk knowledge
- accessibility of information
- expandability of knowledge capture.
- adaptability for varying type of projects.
- security for risk information.

2. Establishing A Risk Management Tracking Database

An essential element of risk management is keeping track of risks. Some JPL projects used a spreadsheet for this purpose. NASA's *faster, better, cheaper* philosophy resulted in a changing project environment, where it soon became apparent that tracking risks might be facilitated with a specialized tool. The relationships between risks did not allow them to be easily categorized in a spreadsheet. These relationships were best organized in a relational database.

The first step in establishing any risk system is defining an organizational structure for the risks. A risk can be placed into one of four categories: Cost, Technical, Schedule, or Resource. Within each of these categories, further sub-categories can be defined. The determination of the categories and sub-categories are project specific and depend upon the needs determined by each project. In the past the categories and sub-categories were often not formalized and were maintained from memory and the personal experience of project management. In order to comply with NASA's NPG 7120.5A requirements, risk management had to become a formalized project process. NPG 7120.5A does not dictate *how* risk management will be done, only that there has to be an approved mechanism for managing a risk, including tracking and disposition.

Properly implementing any risk management tracking database should include the categorization, impact classification, and likelihood classification of the risks. These three areas are very project specific and require project consensus before implementation. Reaching a consensus on these areas can be very time consuming.

The risk tolerance of a project also determines the organization of the risk data and the disposition of risks. To gain complete insight into a project's risk and to allow a complete picture to how much risk exists, all risks should be entered into the database. The Risk Management Tracking Tool captures data on risks, but does not make decisions based upon that data. The decision making process is left to the experts, the risk manager, and the project manager. A good risk management system only aids in the organization and planning of the risks and is not meant to replace the human decision making process.

Risk Management Knowledge Capture

The main requirement of any risk management tracking system is to capture all phases of the life cycle of a risk. The life cycle of a risk includes the identification, analysis, disposition, and whether the risk occurs. The Risk Management Tracking Tool was designed to track all revisions of a risk and to comply with ISO 9000 [3] standards. Tracking the risk provides the basis for a comprehensive analysis after the completion of a project.

NPG 7120.5A defines risk management as a continuous process [1] that:

- identifies risks;
- analyzes their impact and prioritizes them;
- develops and carries out plans for risk mitigation, acceptance, or other action;
- tracks risks and the implementation of mitigation plans;
- supports informed, timely, and effective decisions to control risks and mitigation plans; and
- assures that risk information is communicated among all levels of a program/project.

According to NPG 7120.5A risk management begins with risk identification and the development of a risk management plan and continues through the disposition and tracking of existing and new risks. Figure 1 shows the risk management process as outlined in NPG 7120.5A.

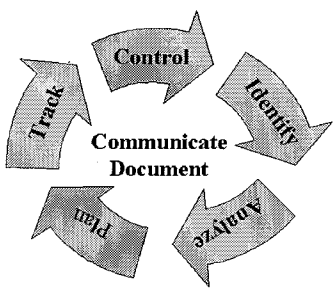

Figure 1. Continuous Risk Management. [1]

In developing a risk management database, a project must consider each of these steps and include them in their risk management plan.

Compliance to NASA NPG 7120.5A Specifications [1]

Within the last 5 years, NASA has adopted the NPG 7120.5A project specification. This specification defines what is required for NASA funded projects. Section 4.2 focuses on the requirements for establishing effective risk management. Section 4.2.2 specifies requirements including those for risk management tracking.

Although NPG 7120.5A does not specify how to track or disposition each individual risk, it does require that a process be developed and implemented for handling the risk life cycle. Risk management functions outlined in NPG 7120.5A are shown in Figure 2. The Risk Management Entry Tool was designed to complement the risk management process. The first implementation was designed to collect and organize risk information.

Organization of Risk Information

Determining how risks will be organized is one of the most important aspects of a successful risk management system. As previously stated, this organizational structure is based on project-specific requirements. Some common areas of

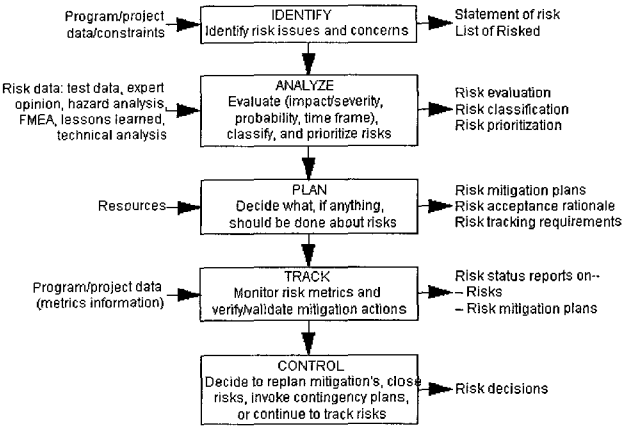

Figure 2. Description of risk management functions. [1]

organization may include risk impact functional area, responsible groups, risk type, etc. Selection of the risk organizational areas will be optimally based on the estimated number of risks for the project and the distribution of risks across the sub-groups. An equal distribution of risks across sub-groups is the best, as sub-groups with too many or too few risks will make it difficult to search, compare, and view risk information.

The risk tolerance of a project will also determine the organization of the risk data. It is important to capture as many risks as possible in the tracking tool in order to provide a comprehensive database of *lessons learned* for future projects.

Security

Security in the Risk Management Entry Tool is based on a three-tiered security model. The tool has the following levels of security: *pending*, *write access*, and *administrative*.

These levels are defined as:

- Pending – Allows the user to see pending risks before the risk has been dispositioned
- Write Access – Allows the user to enter risks into the database
- Administrative – Allows the user to change the risk state, change a user's access privilege, and allow access to special risk form fields.

The Administrative access also allows the risk manager to step a risk through the its lifecycle. The lifecycle is broken down into the following risk states.

- Pending – Initial state of a risk. No analysis has been done to evaluate the validity of the risk.
- Under-review – The risk has been evaluated and has been determined to be a valid risk and further information is being gathered to disposition the risk.

- Evaluated – The risk disposition has been determined and a decision has been made to either accept or mitigate the risk.
- Retired – The risk window for the risk has closed and the risk is now longer an issue. This may or may not mean that the risk has occurred.
- Rejected – It has been determined that the risk is not a viable risk. The risk entry will only be maintained for historical purposes.

By implementing the above security, the risk system maintains tight control over which functions are available to which users.

Accessibility

The Risk Management Entry Tool is web based and allows password-protected accessibility from anywhere on the internet. Additional interfaces to enter the risks are also available through MS-Access and MS-Excel. Accessibility was considered one of the most important requirements of this tool. It was determined that anyone should be able to enter risks and have those risks evaluated by the risk manager.

The risk system provides three interfaces to enter risk information. These include two web interfaces, one for the wizard and one for the advanced form. The wizard allows the novice risk user to step through questions that are applicable to the risk complete a risk entry. The advanced form is a single screen that allows easy use of the tool enter a risk. The third interface is through direct access of the database. This mechanism can be used to update the risk system through direct modification and allow bulk loads of risk information directly using the internet and the direct uploading of risk information using a MS-Excel spreadsheet.

Expandability

The Risk Management Tracking Tool is based on an MS-Access database. MS-Access was determined to be the most cost-effective solution as the only cost is associated with the availability of interface tools and the licensing of the COTS software. The cost of implementing this Risk Management Entry Tool includes the cost of MS-Access for those people who require direct access to the database and report generation procedures. The Risk Management Tracking Tool can be expanded to use different databases, from SQL Server, Oracle to other database systems.

Adaptability

Adaptability was another important requirement of any system developed. Information to be tracked for a risk had to be flexible to allow the addition of multiple data elements based upon project needs. Furthermore, common data elements are maintained across multiple projects to provide a commonality between the projects. By implementing a common tool baseline, the Risk Management Tracking Tool can implement enhancements across multiple project baselines.

Reports for Project Management

Simplicity is the keystone of the Risk Management Entry Tool's report management. Any risk management system should have a flexible report-writing interface and the more commonly used reports should have the capability of being hosted on the web. One suggested report interface used is the report writer from MS-Access. This interface is primarily used to for specific report generation for presentations as shown in Figure 3.

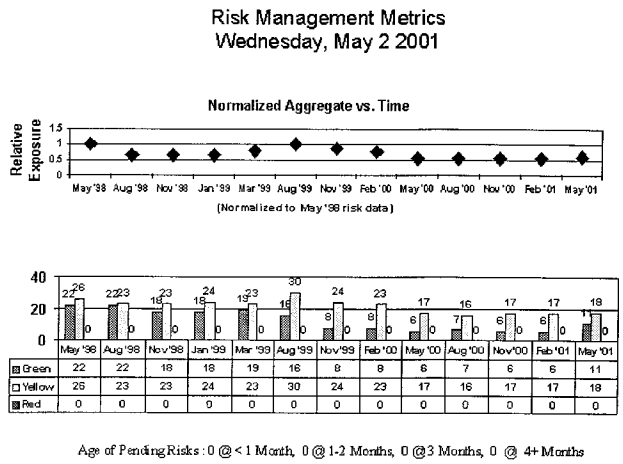

Figure 3. Sample Presentation Risk Report

3. THE SIRTF PROTOTYPE

Risk Management Knowledge Capture

SIRTF chose a web interface for capturing its risk knowledge. This interface makes it possible for geographically distant partners to access the risk information and supply risk inputs. A portion of SIRTF's web interface for adding risks to the database is shown in Figure 4.

NPG 7120.5a Compliance

The SIRTF database and associated web interface was designed to comply with the NPG 7120.5A guidelines, however it is the SIRTF Mission Assurance Manager who takes responsibility for the processes involved with meeting compliance. This results in the manager using the database as a tool when performing the following tasks:

- identifing risks and seeing that others identify risks;
- analyzing risk impacts and prioritizing the risks;
- developing and carrying out plans for risk mitigation, acceptance, or other action;
- tracking risks and the implementation of mitigation

plans;

- supporting informed, timely, and effective decisions to control risks and mitigation plans; and
- assuring that risk information is communicated among all levels of a program/project.

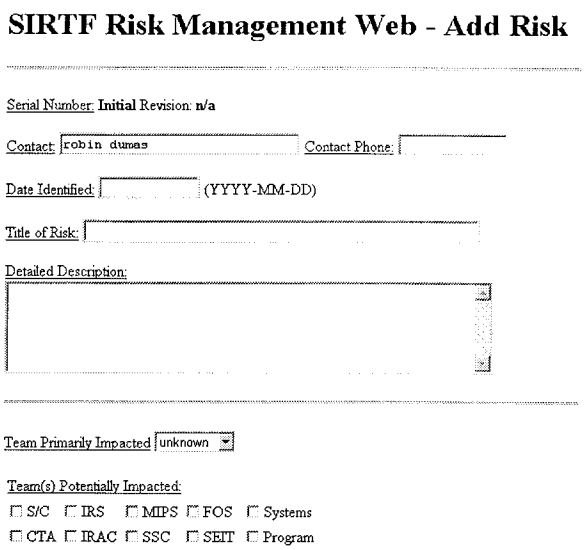

Figure 4. Sample of Adding a Risk to SIRTF's database via web interface.

Organization of Risk Information

The SIRTF Mission Assurance Manager worked with IT personnel in designing the database, which resulted in the SIRTF impact categories that describe the impact the risk would have on the project. These impact categories and their definitions include:

- High — The impact of occurrence is not reparable within remaining resources ($, mass, power, schedule, memory, etc.) allocated to a single system provider, or Level 1 requirements are at risk.
- Significant — The impact of occurrence may not be reparable within remaining resources allocated to a single system provider, or impacts may degrade compliance with Level 1 requirements.
- Low — The impact of occurrence is reparable within remaining resources allocated to a single system provider, and Level 1 requirements are not at risk.
- Negligible — The impact of occurrence is easily reparable within remaining resources allocated to a single system provider, and Level 1 requirements are not at risk.

In addition, the SIRTF Likelihood Categories were developed and describe how likely it is that a risk will occur. These categories and their definitions include:

- High — Occurrence is very likely.
- Significant — Occurrence is likely.
- Low — Occurrence is unlikely.
- Negligible — Occurrence is very unlikely.

An additional category is the teams impacted by a risk. The SIRTF teams are comprised of 8 geographically distributed systems providers. Each has been given a category in the risk system through which risk ownership and potential

impacted is defined. The SIRTF status categories include Accept, Under Review, Pending, and Rejected. The SIRTF web interface provides the capability of sorting risks by Risk Number, Team, Date Updated, and Status. The data is sorted by clicking on the appropriate title. The information is then resorted in ascending order for that category. Sub-sorts of information are provided through links provided at the end of the table. Figure 5 shows a sample of the SIRTF Risk Management Directory.

SIRTF Risk Management Directory

Select the risk entry that you wish to view/modify or Add a new risk:

Current Display: **All Risks w/Pending**
Date: **2001-10-02**

#	Team	Updated	Status	Title
	Program		Accept	
	CTA		UnderReview	
	SEIT			
	S/C		Accept	
	Systems			
	IRAC		Accept	
	IRS		Accept	
	MIPS			

Figure 5. SIRTF Risk Management Directory via web interface.

Reports

The SIRTF Mission Assurance Manager asked for several reports including the SIRTF Risk Summary shown in Figure 6. Additional reports include a quarterly report summary and a risk summary schedule.

SIRTF Risk Table Summary - All Risks

Likelihood	Negligible	Low	Significant	High
High				
Significant				
Low				
Negligible				

Impact

Risk Classifications		Pending*	UnderReview	Accept	Total
Not a mission threat					
Potential threat to mission success	Yellow				
Significant and likely threat to mission success					
	Total				

* Pending risks are note include in UnderReview and Accept risk table give above

Figure 6. SIRTF Risk Summary.

4. Lessons Learned

The process of handling and dispositioning risk is the emphasis in any risk management plan. Risk management tools only in the analysis. Decisions made are still human in value and nature.

Categorization of risks is important. Granulation of the categories is essential to group similar risks together to gain an insight before a decision is made. The granulation should not be so detailed that only one risk will fall in each category.

All risk management processes and systems are a reflection of the project management methodology and style.

5. Adaptability to Various Levels of Project Complexity

The Risk Management Entry Tool used by SIRTF was designed and implemented to accommodate project complexity and changes that would occur throughout the project lifecycle. The SIRTF Risk Management Entry Tool provided a common interface between knowledge experts and the program management. Adapting the risk database to a more complex structure was simple. The difficult issue was to design extensible user interfaces that would easy to use by a facilitate input from users of various computer skill levels. The user form, simplified risk wizard input, and remote upload capability. Common interface reports were converted to be database driven in structure and are customizable at installation.

6. Conclusion

Whatever risk management system that a project uses, the project must decide the risk tolerance, important aspects to track, definitions of the impact and likelihood classifications, and the method which risks are handled. Without these issues being addressed, a successful implementation of any risk management system is highly unlikely.

NASA funded projects are required to abide by NPG 7120.5A guidelines. Projects must implement procedures and processes and document on how risk management will be accomplished. The Risk Management Entry Tool developed for the SIRTF project provides a consistent way of managing risks and was implemented to provide effective communication, ease of use, data analysis, and provide a source of lessons learned.

This SIRTF implementation of a web-based system has been further refined to accommodate the needs of other projects, and to further assist a project in NPG 7120.5A compliance. The Risk Management Entry Tool can be configured to provide the flexibility to track information either qualitatively or quantitatively. Either configuration can be easily tailored to meet the needs of a project based on project requirements and to provide simulation capabilities to the risk administrator.

Acknowledgement

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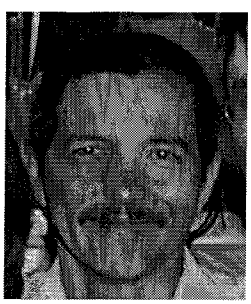
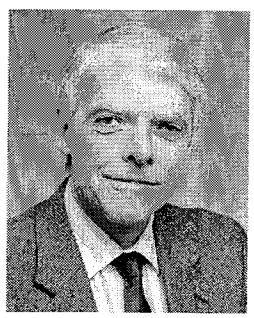


Keevin Fisher is currently working as a Manager of the Project Information Enterprise Resources Group at Raytheon ITSS in Pasadena. His areas of technical expertise include programming, database design, information management technologies, and knowledge management. He has been recognized by NASA for his risk management efforts and has supported the development of the SIRTF risk management web site. He has been the prime programmer converting the risk management tool to 15 other JPL projects including Cassini, GALEX, Mars Sample Return, Tropospheric Emission Spectrometer. He oversees the design and implementation and enhancements for the risk management entry tool, and is currently responsible for over-seeing the Raytheon ITSS contract for the group. He is currently completing his BSIT degree.

George Greanias, received his B.S. degree in Mechanical Engineering from UCLA in 1982, and his Masters of Science in Engineering Management from CSUN in 1990. He has received numerous group achievement awards from NASA for his support of Cassini spacecraft and instrument payload, Galileo, Upper Atmosphere Research Satellite/Active Cavity Radiometer, and the Soft X-ray Telescope Camera. He has developed a web based risk management program for the Space Infrared Telescope Facility (SIRTF) that has been adapted for multiple JPL projects. In October 2000, NASA has awarded him a Certification of Recognition for his development of Web Based Risk Management. From his initial assignment supporting Galileo dynamic and thermal requirements he has supported multiple JPL flight projects both planetary and Earth orbiters, and completed a Product Assurance Trainee rotation program through JPL Environmental, Reliability, Quality Assurance, Electronic Parts, organizations. Recently he has provided the leadership of the SIRTF Mission Assurance and Risk Management programs.



Jim Rose is an Engineer Principle at JPL, and the process owner of the JPL process "Manage and Mitigate Risk". He is a spacecraft systems engineer by background, and has worked on Planetary and Earth orbiting missions for 32 years. Before the Risk Management assignment, he was the Project Engineer on the highly successful TOPEX/Poseidon Oceanographic satellite. As process owner, his responsibilities include documenting, teaching and assisting in the implementation of Risk Management on all JPL Flight Projects and Programs.

Robin Dumas is a senior information systems engineer at the Jet Propulsion Laboratory. She currently works as the Information Technology Manager for the SIRTF and GALEX projects at JPL. She is also a Contract Work Order Manager for the Project Information Enterprise Resources at JPL. She has received numerous group achievement awards from NASA for her support of Voyager, Galileo, TOPEX/Poseidon, PDS, and IRAS, as well as JPL awards for excellence and leadership in developing and managing project information systems for various flight projects. She is responsible for designing, implementing, and maintaining the project information systems. She is also responsible for implementing and maintaining a collaborative meeting environment that connects geographically diverse project partnering institutions. Her information technology fields of expertise include web applications, databases, information management technology, and knowledge management. She is currently participating in research in the fields of asteroid astrometry and infrared astronomy. She has an AA degree and is currently completing a BSIT degree.